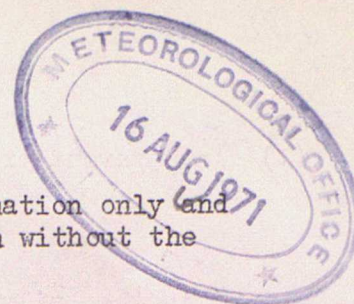


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AGRICULTURAL MEMORANDUM No 386

Dr M Hough

THE EFFECTS OF THE WEATHER ON THE YIELD OF MAIZE IN BRITAIN (2)

Ag. Mem. 385 discussed the variation of grain maize yield in terms of correlations with temperature, radiation, rainfall and soil moisture. This note compares actual grain yields with estimates of potential photosynthesis (i.e. water non-limiting) calculated by Monteith's (1965) method, modified according to temperature. Budyko (1968) has also presented a nomogram which gives the mass of material produced by photosynthesis when temperature and radiation are available as monthly means for each hour of the day. This nomogram appears to have been drawn for cool temperate crops since maximum production of dry matter occurs at a relatively low temperature (20°C). It has been shown by Moss (1965) that the tropical grasses show maximum production at air temperatures between 25°C-30°C with a rapid decline for low temperatures. Moss's figures of the photosynthesis of maize and its variation with temperature have been combined with Monteith's method for calculating potential photosynthesis, with the following results:-

The Method

The variation of gross photosynthesis P with light intensity I is given by,

$$P = (a + \frac{b}{I})^{-1}$$

a and b are constants. Monteith suggests $b = 0.05 \text{ cal/gm. (all crops)}$; $a = 0.5 - 0.75 \text{ m}^2 \text{ hr/gm. (temperate crops)}$; $a = 0.25 \text{ m}^2 \text{ hr/gm. (maize)}$. It is assumed that the value of $a = 0.25$ corresponds to a temperature of 30°C and Moss's data have been used to find the variation of ' a ' with temperature. Figure 6 is a suggested variation of $1/a$ with temperature.

In order to use Monteith's Method, the areas of sunlit and once-shaded leaves have to be found.

Sunlit area: $A_0 = (1 - S^L)/(1 - S)$

Once-shaded area: $A_1 = (1 - S^L - (1 - S)L S^{L-1})/(1 - S)$

S is the fraction of incident radiation which passes through unit leaf area without interception. For grasses the value $S = 0.7$ is used.

L is the leaf area index, taken as 4 for a mature maize crop.

Using these values for S and L , we get:

$$A_0 = 2.53; A_1 = 1.16$$

It is then necessary to calculate:

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- (1) An apparent mid-day radiation intensity I^* (cal/sq. cm./min.), given by:

$$I^* = \frac{\pi R}{2h}$$

R is the daily radiation total (cal/sq. cm.).

h is the duration of daylight (min.).

- (2) A number n , where:

$$n = (a(1-S)I^* - b) / (a(1-S)I^* + b).$$

The daily total of photosynthesis P (gm/m²/day) is given by:

$$P = \frac{h}{a} \left[A_0 (1 - f(n_0)) + A_1 (1 - f(n_1)) \right]$$

h is here measured in hours.

The functions $f(n_0)$ (for sunlit leaves), $f(n_1)$ (for once-shaded leaves) are given by:

$$f(n) = \frac{1}{\pi} \cdot \frac{1-n}{\sqrt{n}} \ln \left\{ \frac{1+\sqrt{n}}{1-\sqrt{n}} \right\} \text{ for } a(1-S)I^* > b$$

$$\text{or } f(n) = \frac{2}{\pi} \cdot \frac{1 + \frac{1}{\sqrt{n}}}{\sqrt{n}} \cdot \arctan \sqrt{n} \text{ for } a(1-S)I^* \leq b.$$

for once-shaded leaves I^* is replaced by $I^*/10$ to find n_1 .

The Calculations

For each year the mean daylight temperature T was found for the month after flowering. Ag. Mem. 16 suggests that this can be found from:

$$T = \bar{X} - F(\bar{X} - \bar{N})$$

$\bar{X}$ is the mean maximum temperature for one month after flowering.

$\bar{N}$ is the mean minimum temperature for one month after flowering.

The value of $F = 0.4$ has been used. (Appropriate to latitude).

Using this value of T in figure 6, a value for $1/a$ was found. Next I^* was obtained from radiation data estimated from mean sun hours per day over the month after flowering and average daylength during this time.

The values of P were multiplied by 31 to give the potential dry matter produced during the month after flowering. Estimates of respiration for maize give a value of about 40% of P , and this value was used to estimate potential actual yields. Table 2 gives the potential actual dry matter production and the actual dry matter yield (for the grain) both expressed in cwt/acre. The ratio of these two values is also given. This ratio varies from 0.83 to 1.37 and so a rough guide to actual yields can be obtained

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from the estimated potential yield calculated from data for the month after flowering. This does not mean that photosynthesis in September does not contribute to the yield, but it does indicate that a preliminary yield estimates could be made at the end of August - about 6 weeks before harvest. If the summer has been unusually dry and warm, then 20% can be deducted from the estimated total to allow for a drought effect. Also, if substantial rain falls on the flowering day then 10% can be added to the estimated total.

Any comments or criticisms should be sent direct to the author.

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August 1971

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Table 2ESTIMATES OF POTENTIAL PHOTOSYNTHESIS (cwt./acre)

YEAR	POTENTIAL PHOTOSYNTHESIS		ACTUAL	<u>POTENTIAL ACTUAL</u>
	GROSS	LESS 40% FOR RESPIRATION	YIELD	ACTUAL
1958	67.84	40.70	45.88	0.89
1959	94.68	56.80	41.41	1.37
1960	64.97	38.98	43.69	0.89
1961	77.25	46.35	41.57	1.12
1964	83.35	50.01	43.35	1.16
1965	56.59	33.95	30.67	1.11
1966	72.64	43.58	46.39	0.94
1967	75.76	45.46	54.76	0.83
1968	65.89	39.53	37.43	1.06
1969	82.81	49.69	51.04	0.97
1970	74.07	44.44	44.03	1.01

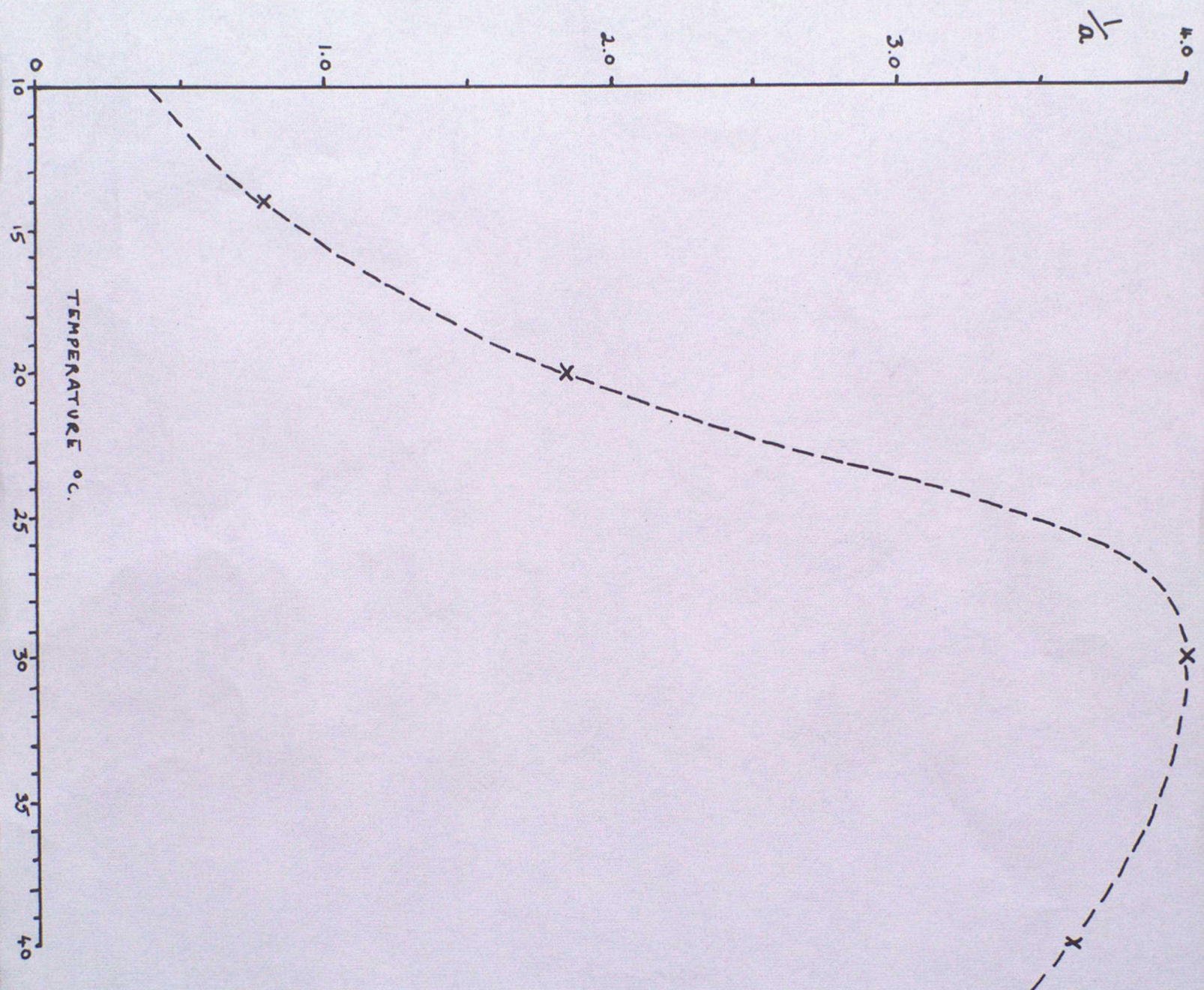


FIGURE 6.
VARIATION OF ' a '
WITH TEMPERATURE.